Wireless Sensing and IEEE 1451

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Outline

- Objectives of the Wireless Sensing Workshop
- Introduction / Background
- State of Industry on Sensor Interfaces
- Sensor Interface Standardization-IEEE P1451
- Summary of IEEE P1451
- Interest in Wireless Sensors
- Acknowledgment

Objectives of the Wireless Sensing Workshop

- Review the latest wireless technologies and their applications.
- Provide an open forum for examining and discussing the appropriateness of these and other technologies for use as wireless sensor interfaces.
- Discuss the requirements of wireless sensor communication interfaces.
- Use previous IEEE P1451 model and experience to explore wireless interface standardization.
- Charter a future action plan

Introduction / Background

- The National Institute of Standards and Technology (NIST) is part of the Department of Commerce's Technology Administration.

- NIST's Mission: To help increase U.S. industry competitiveness through advanced research, standards, and technology collaboration.

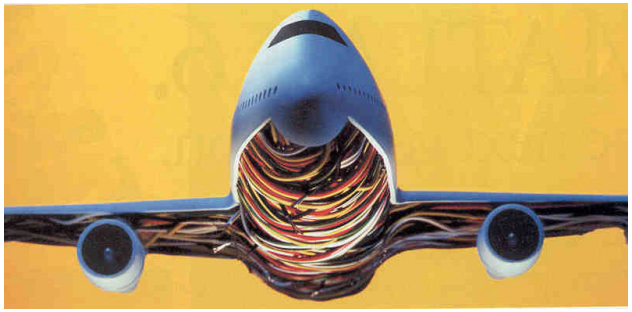
- The Sensor Development and Application Group at NIST has been working with industry and IEEE - establishing the Smart Transducer Interface Standard, IEEE 1451.

State of Industry on Sensor Interfaces

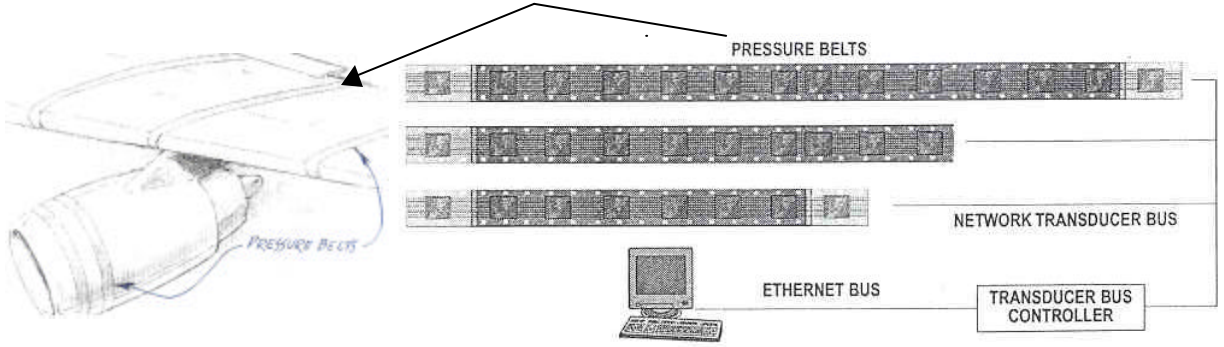
- Smart features integrated into sensors and actuators.
- Increasing uses of digital communication and networked configurations for connecting sensors and actuators.
- The trend is moving toward distributed measurement and control, and distributed intelligent sensing architecture.
- Networked sensor technology applied to commercial and consumer applications in
  - process control,
  - industrial automation,
  - automotive,
  - aerospace,
  - to smart buildings and homes
  - etc...

State of Industry - cont'd

- Networked sensors are needed
  - *Example:* US Navy needs tens of thousands of networked sensors per vessel to enhance automation because of the reduced-manning program.
  - *Example:* Boeing needs to network hundreds of sensors to monitor and characterize airplane wing performance. Boeing would benefit by using networked sensors and actuators to reduce the amount of wiring.



Picture courtesy IEEE



Pictures courtesy Endevco

State of Industry - cont'd

- Barriers:
  - Large number of different networks to support.
  - Significant sensor interface software development for each network.
  - Lack of network software know-how and support by sensor manufacturers.
  - *Lack of a standardized sensor interface.*
  - These hold back the speedy development and adoption of smart sensors.

Why Networking Sensors?

Networking sensors provides advantages not readily available with traditional sensors, they:

- significantly lower the total system cost by simplified wiring
- enable self-describing of sensors
- allow multi-variable sensor configuration
- enable time stamp of the measurements
- enable embedded processor or ASIC implementation
- ease software configurability
- enable bi-directional digital communication
- communicate messages in standardized digital format
- provide Internet connectivity, thus global, or *anywhere*, access of “sensor information”

Sensor Interface Standardization - IEEE P1451

- A set of standards aimed to simplify transducer (sensor or actuator) connectivity.

- It is developed as:
  - an ***open***, industry consensus standard with participation from sensor, measurement, and control network industries, and users.

- It's purposes are to**:**
  - provide a set of common interfaces for connecting sensors and actuators to ***existing*** instruments, and control and field networks.
  - provide an easy upgrade path for connecting transducers, instruments, or networks from ***any*** manufacturer.

What Standards are being developed ?

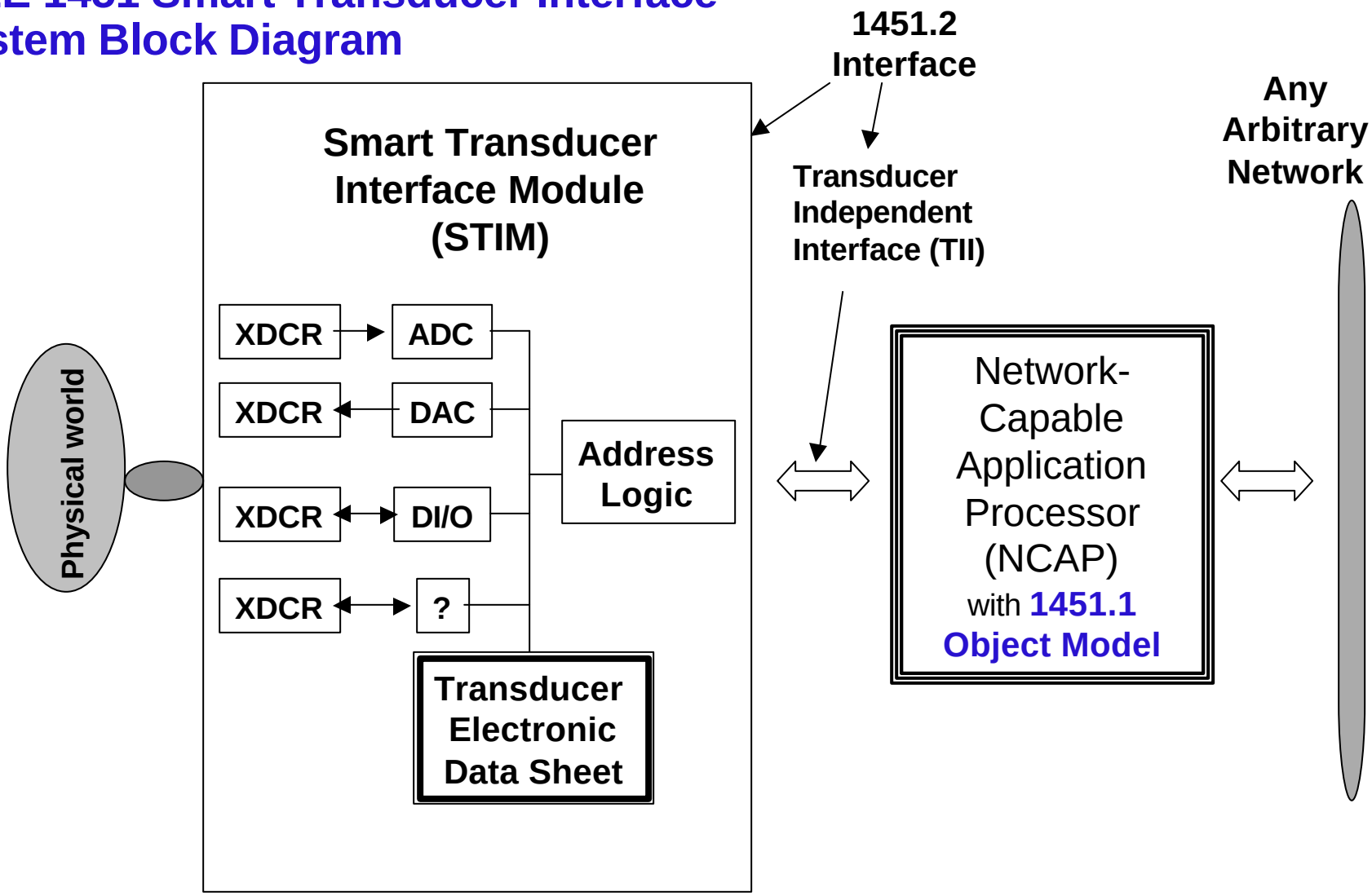
- **IEEE Std 1451.1-1999,** Network Capable Application Processor (NCAP) Information Model for smart transducers -- *Published standard.*

- **IEEE Std 1451.2-1997,** Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats -- *Published standard.*

- **IEEE P1451.3,** Digital Communication and Transducer Electronic Data Sheet (TEDS) Formats for Distributed Multidrop Systems -- *Being developed.*

- **IEEE P1451.4,** Mixed-mode Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats -- *Being developed.*

IEEE 1451 Smart Transducer Interface System Block Diagram

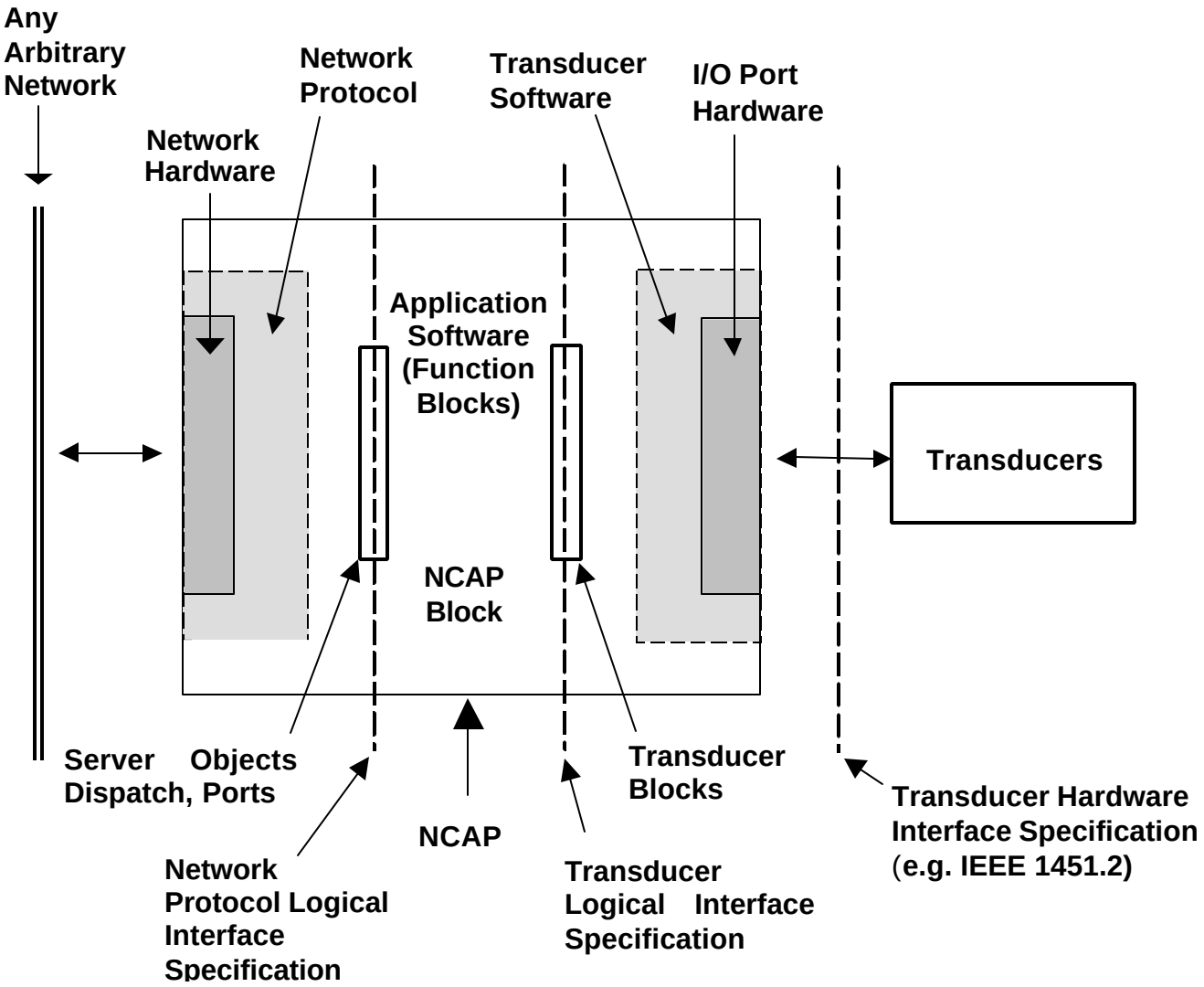


IEEE 1451.1
NCAP Information Model for Smart Transducers

By defining a common object model for the components of a networked smart transducer, together with interface specifications to these components, the Standard provides:

- Network protocol logical interface specification (via Server Object Dispatch and Ports)
  - Software interfaces between application functions in the NCAP and the network in a manner independent of any specific network
- Transducer logical interface specification (via Transducer Block)
  - Software interfaces between application functions in the NCAP and the transducers in a manner independent of any specific transducer driver interface

IEEE 1451.1 Networked Smart Transducer Model



IEEE 1451.2
Transducer Electronic Data Sheet (TEDS)

- **Meta-TEDS**
  - Data structure related information
    - version number
    - number of implemented channels
    - future extension key
    - ...
  - Identification related information
    - manufacturer's identification
    - model number
    - serial number
    - revision number
    - date code
    - product description
    - ...

IEEE 1451.2
Transducer Electronic Data Sheet (TEDS) - cont'd

- **Channel TEDS**
  - Transducer related information
    - lower range limit
    - upper range limit
    - physical unit
    - unit warm-up time
    - uncertainty
    - self test key
    - ...
  - Data Converter related information
    - channel data model
    - channel data repetitions
    - channel update time
    - channel read setup time
    - channel write setup time
    - data clock frequency
    - channel sampling period
    - trigger accuracy
    - …

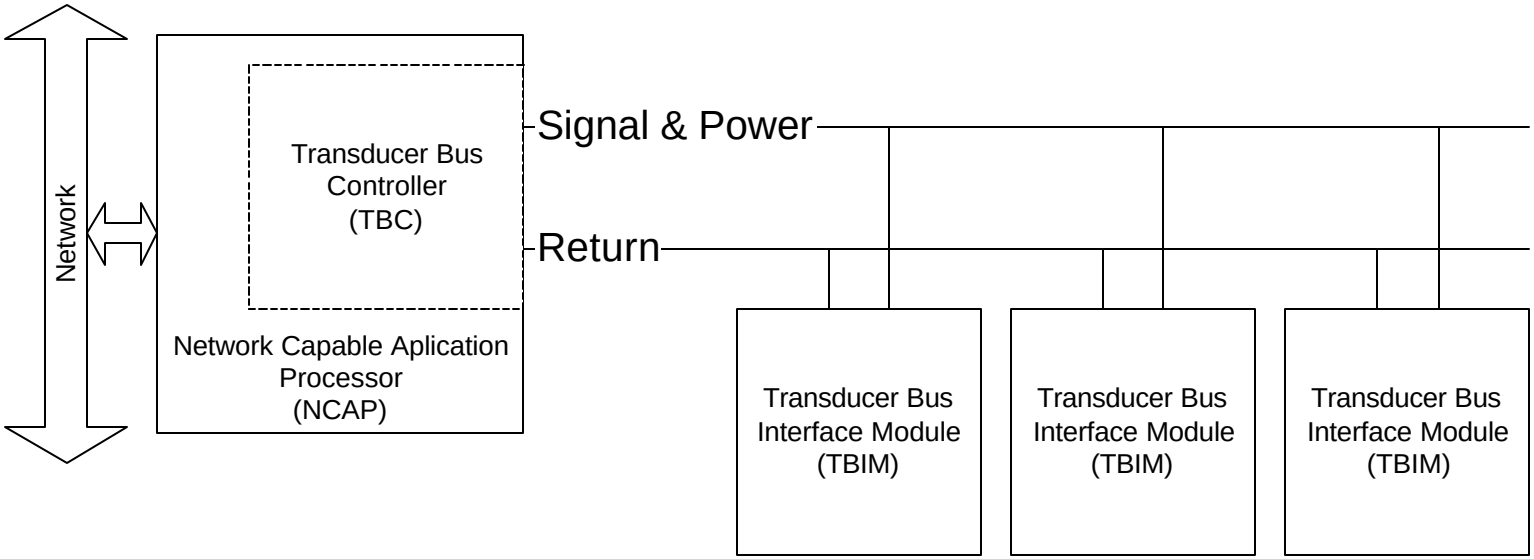
IEEE 1451.2
Transducer Electronic Data Sheet (TEDS) - cont'd

- **Calibration TEDS**
  - Data structure related information
    - Calibration TEDS length
  - Calibration related information
    - last calibration date-time
    - calibration interval
    - number of correction input channels
    - multinomial coefficient
    - ….
  - Data integrity information
    - checksum for calibration TEDS

IEEE P1451.3
Distributed Multidrop System

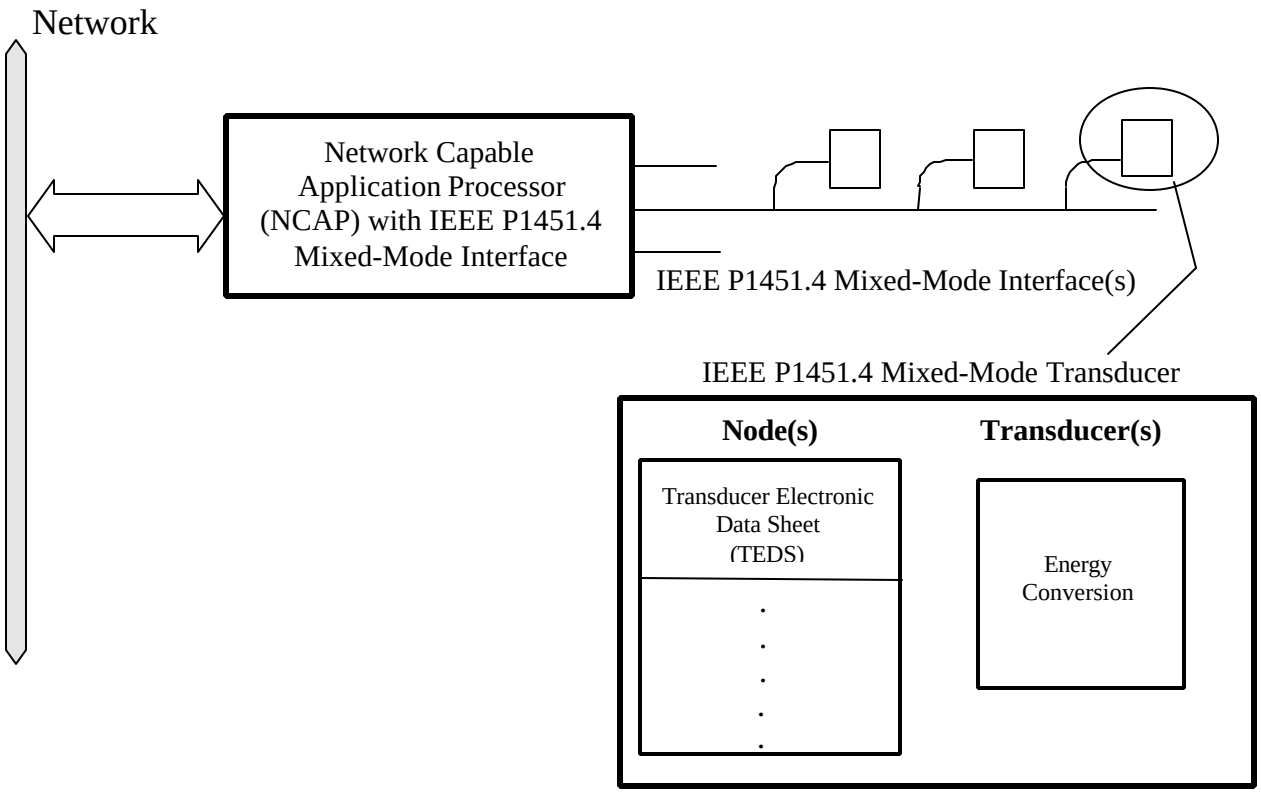
- Synchronously reads large arrays of sensors at high speed in a parallel transducer bus setting.

- Supports sensors with bandwidth requirements to several hundred kilohertz and time correlation requirements in the range of nanoseconds.



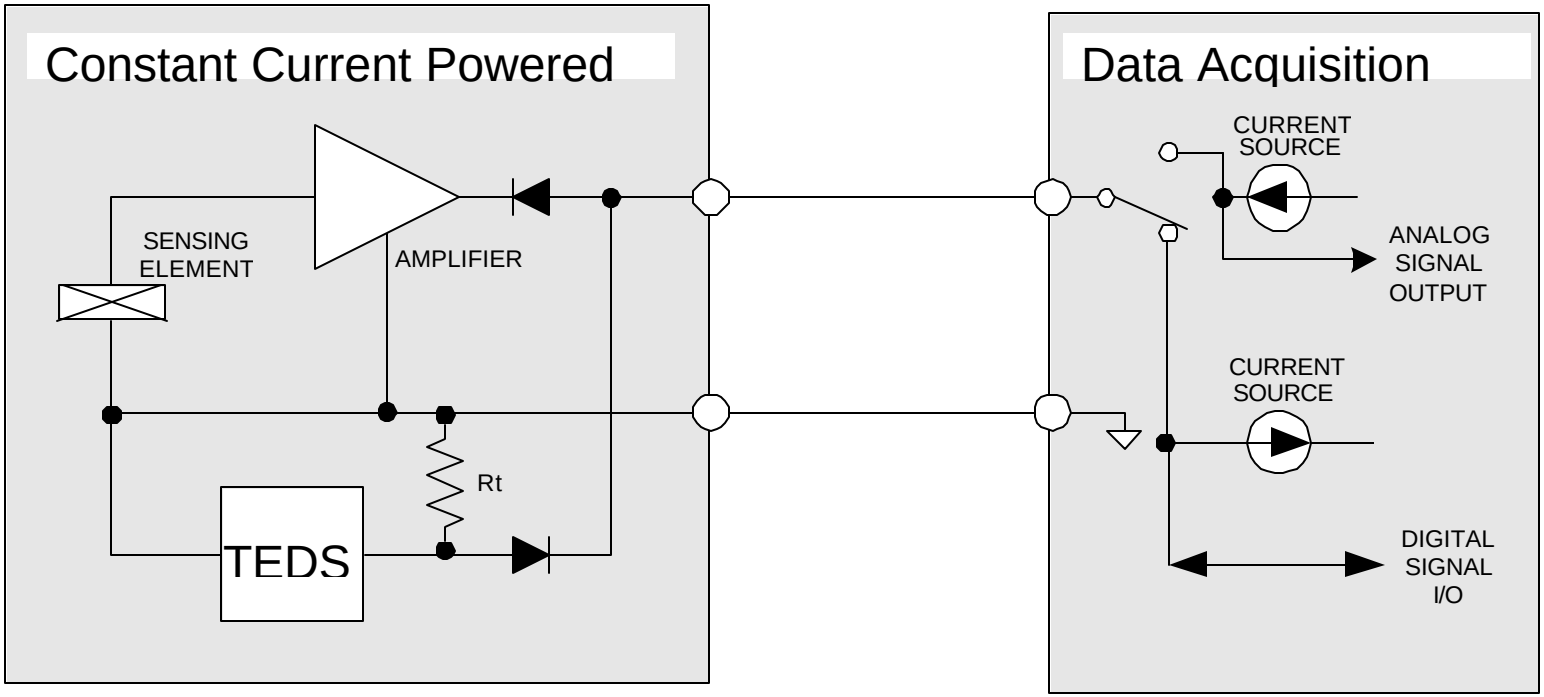
IEEE P1451.4
Mixed-mode Transducer and Interface

- simple, low-cost connectivity (2-4 wires) of analog sensors with TEDS.
- Support existing or legacy data acquisition systems with TEDS.



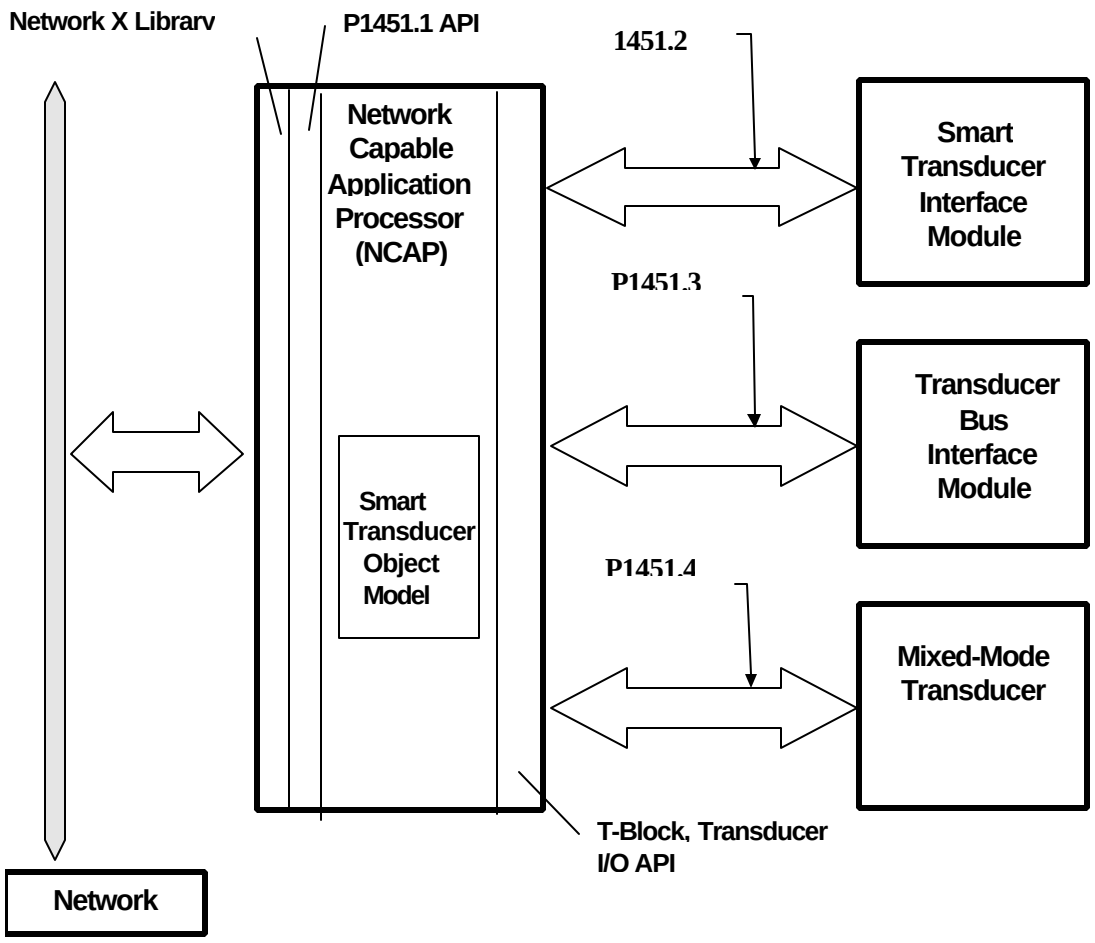
IEEE P1451.4 Mixed-mode Interface

Using Two- Wire Scheme for sending Digital TEDS and Analog Data



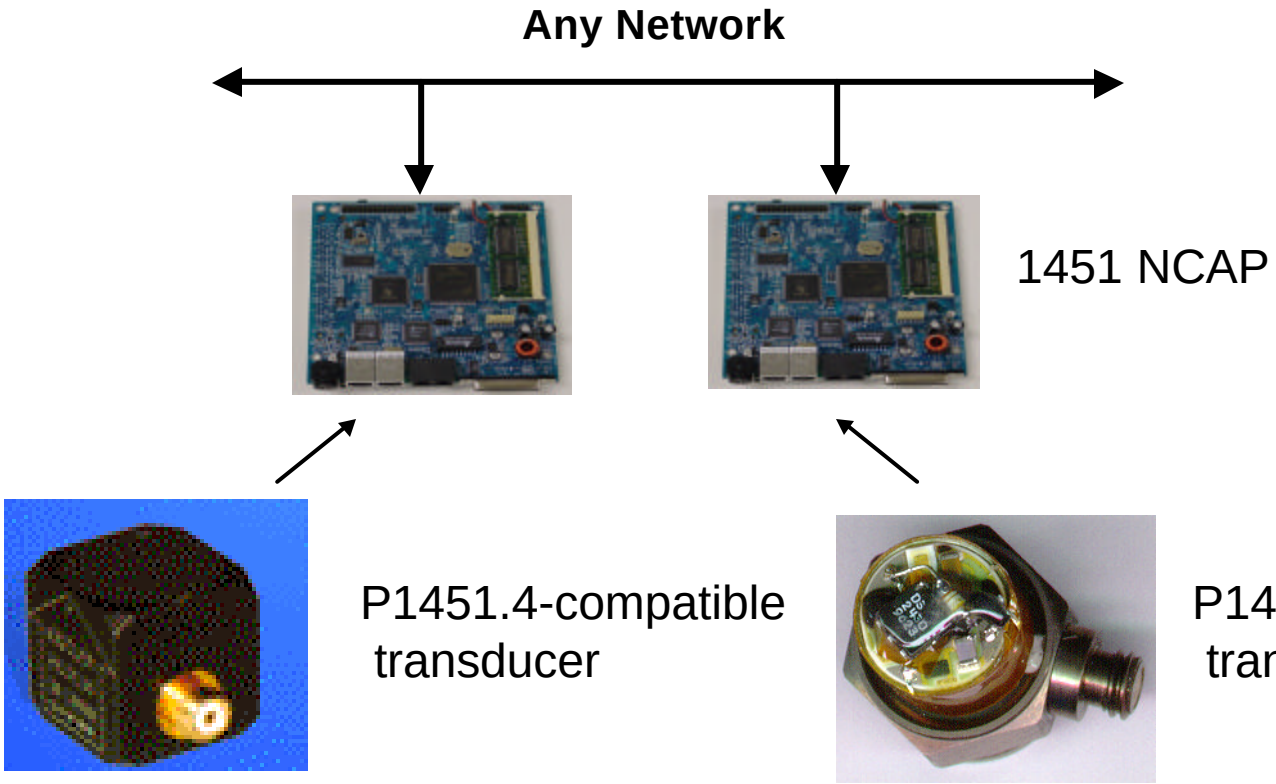
Summary

IEEE P1451 Family Member Independence

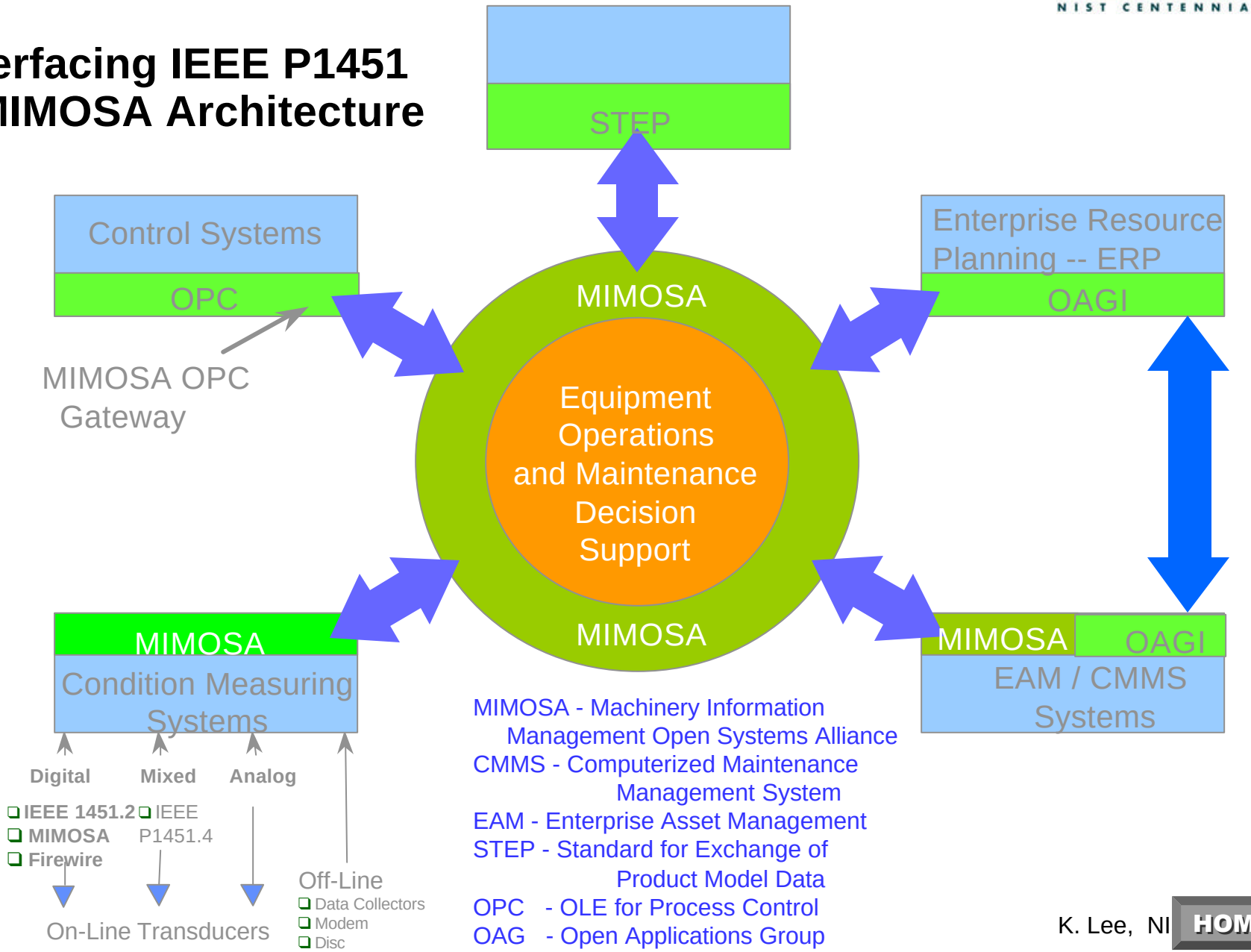


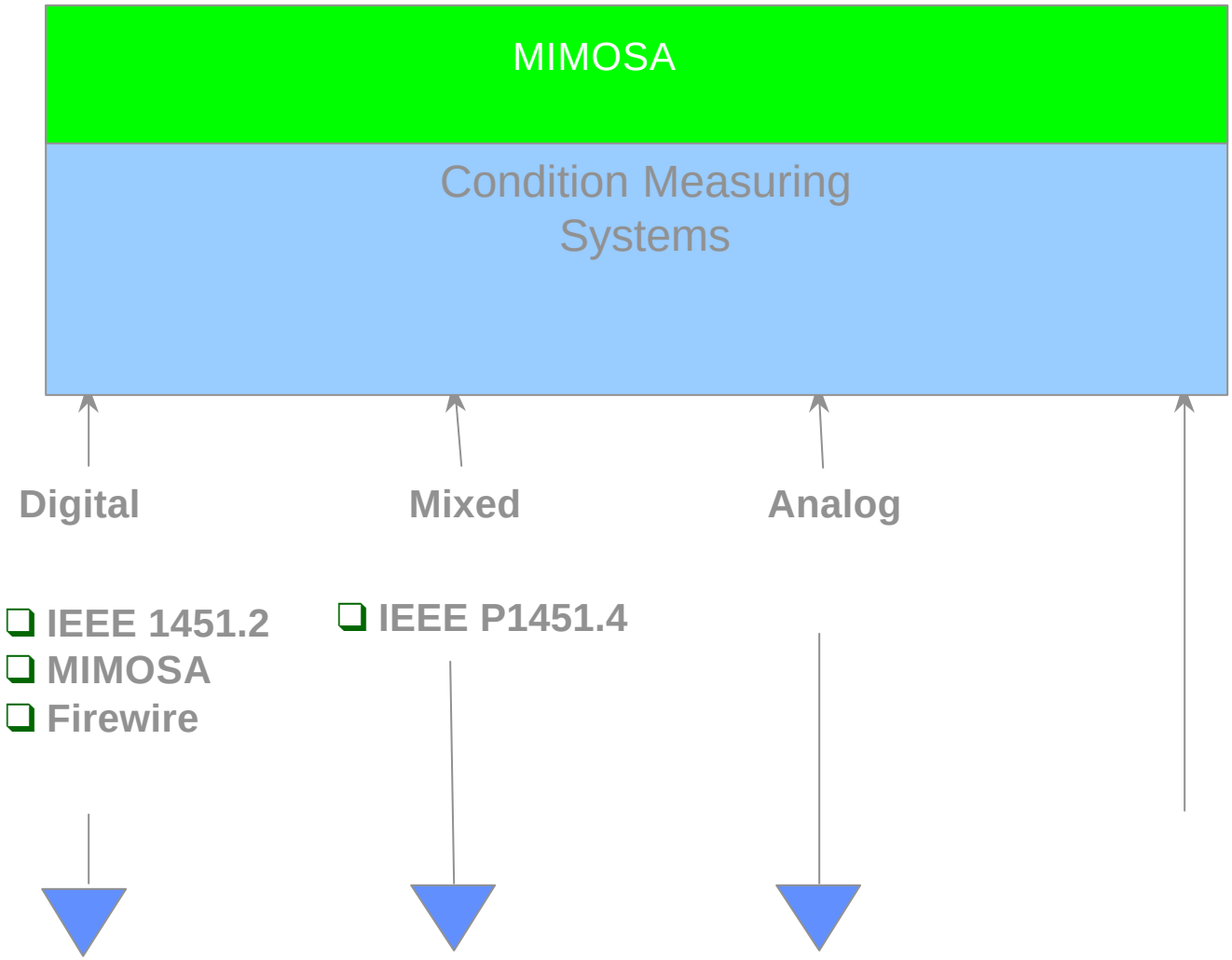
- The proposed standards are being designed to work with each other.
- However, each proposed standard can also be used by itself, independent of the others.

IEEE P1451
Enables “Plug and Play” of Transducers to networks



Interfacing IEEE P1451 to MIMOSA Architecture

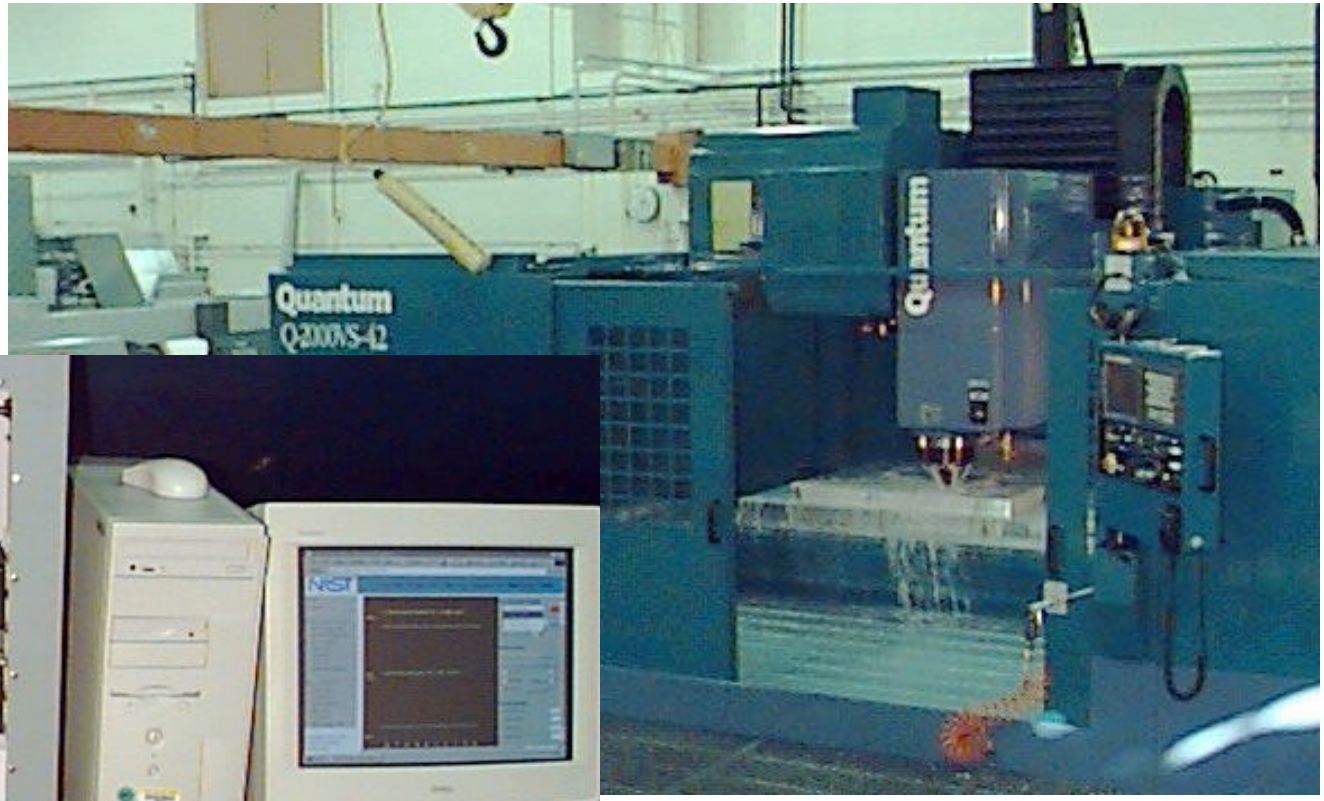


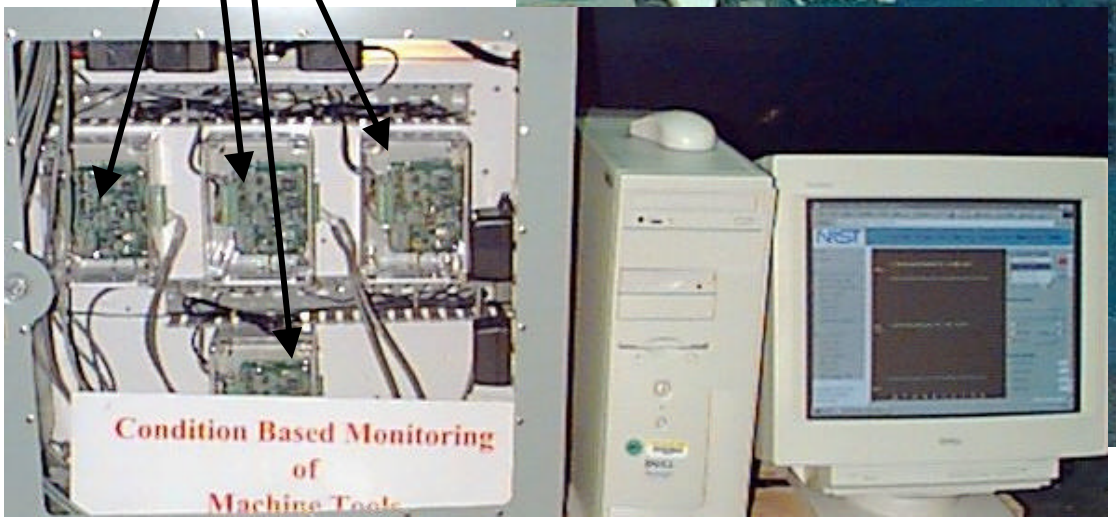

MIMOSA
Condition Measuring Systems
Digital
Mixed
Analog
❑ IEEE 1451.2
❑ MIMOSA
❑ Firewire
❑ IEEE P1451.4

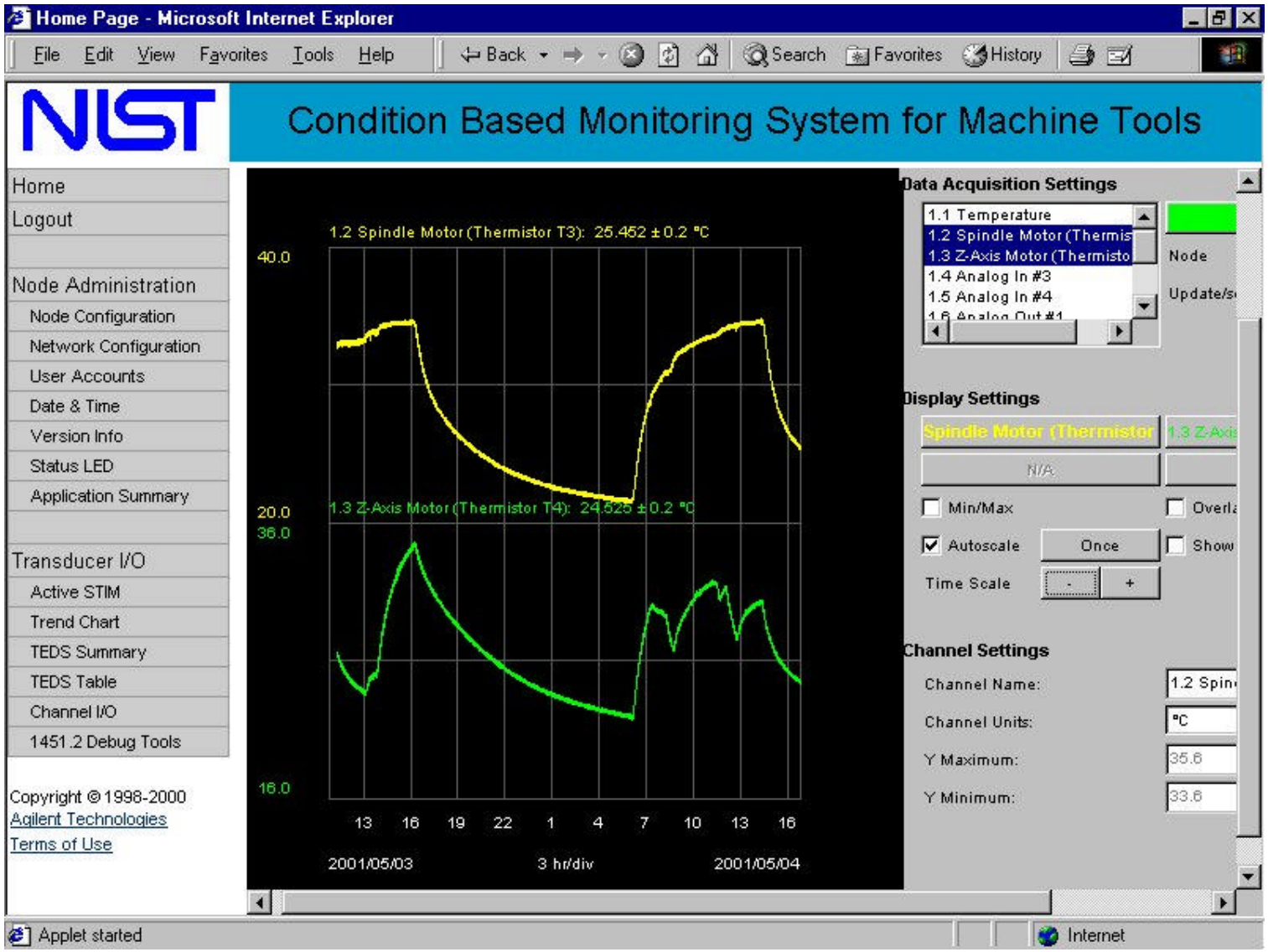
Machine Condition Monitoring in the Shop

- Temperature sensors monitor spindle motors, bearings, axis drive motors.
- Allow monitoring of sensors over the Internet via any common web browser.

NCAP & STIM
in each box






Home Page - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites History
NIST
Condition Based Monitoring System for Machine Tools
Home
Logout
Node Administration
Node Configuration
Network Configuration
User Accounts
Date & Time
Version Info
Status LED
Application Summary
Transducer I/O
Active STIM
Trend Chart
TEDS Summary
TEDS Table
Channel I/O
1451.2 Debug Tools
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1.2 Spindle Motor (Thermistor T3): 25.452 ± 0.2 °C
40.0
1.3 Z-Axis Motor (Thermistor T4): 24.525 ± 0.2 °C
20.0
36.0
16.0
13 16 19 22 1 4 7 10 13 16
2001/05/03
3 hr/div
2001/05/04
Data Acquisition Settings
1.1 Temperature
1.2 Spindle Motor (Thermis
1.3 Z-Axis Motor (Thermisto
1.4 Analog In #3
1.5 Analog In #4
Node
Update/s
Display Settings
Spindle Motor (Thermistor
N/A
Min/Max
Autoscale
Once
Show
Time Scale
Channel Settings
Channel Name:
Channel Units:
°C
Y Maximum:
35.6
Y Minimum:
33.6
Applet started
Internet

Wireless Technology is Here

- Traditional proprietary wireless communication protocols could be expensive to implement.
- Wireless capability is being designed into laptop computers, desktop computers, personal data adapters (PDA), and hand-held computers and devices.
- The popular wireless standards are Bluetooth (or IEEE P802.15) and Wireless Ethernet (IEEE 802.11b).
- Wireless communications have revolutionized the cellular phone industry and provide low-cost electronics for a mass market. This could provide a low-cost base for possible wireless sensor applications.

Interest on Wireless Sensors in Industry

- Machinery condition-based monitoring is one of many examples that can use wireless sensor technology,
  - quick installation and thus reduced installation cost.
  - improve ability to easily and quickly re-configurate the data acquisition and control system.
  - ability to connect measurement data to the Internet.
- Industrial Automation Study Group of the Bluetooth Special Interest Group (SIG) is in full action pursuing the establishment of a working group.
- *Question: Can we use existing wireless technologies for sensor connectivity in a networked environment ?*

Acknowledgment

- Thanks to Sensors Magazine, IEEE I&M Society and NIST for their support and co-sponsorship of the workshop.